INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

Design Memorandum No. 07-04
Technical Advisory

February 6, 2007

TO: **All Design, Operations, and District Personnel, and Consultants**

FROM: ***/s/ Anthony L. Uremovich***
Anthony L. Uremovich
Design Resources Engineer
Production Management Division

SUBJECT: **Backfilling and Video Inspection for Drainage Structures**

REVISES: ***Indiana Design Manual*** **Section 17-2.9**

EFFECTIVE: **March 7, 2007, Letting**

I. BACKFILL MATERIALS

A. Structure Backfill

Structure backfill is a separate pay item. When estimating the quantity of structure backfill, the following should be considered.

1. Drainage Structure. Section II herein discusses the procedure for estimating structure-backfill quantities for a drainage structure.

2. Abutment. The amount of structure backfill should be determined and shown similarly to that for a concrete retaining wall, i.e., 1:1 backslope to a point 1.5 ft (5 m) outside the neat lines of the abutment footing. See *Indiana Design Manual* Section 17-4.05(01).

3. Retaining Wall. The amount of structure backfill should be determined and shown on the cross sections at each retaining wall location. *Indiana Design Manual* Section 17-4.05(02) provides additional information regarding retaining-wall structure backfill.

B. Flowable Backfill

Flowable backfill is a separate pay item. It is required for backfilling behind the end bents of a reinforced-concrete slab bridge, or behind the wingwalls of a precast-concrete three- or four-sided structure. It is also required for backfilling a new cross-culvert placed under an existing roadway.

II. DETERMINING PIPE-BACKFILL QUANTITIES

The determination of pipe-backfill quantities is based on the pipe shape, pipe-interior designation, backfill method, and backfill material.

For additional guidance on determining pipe-backfill quantities, see the INDOT *Standard Specifications* or the INDOT *Standard Drawings*, or contact the Production Management Division's Design Resources Team.

A. Background Information

1. Pipe Shape. The pipe shape is either circular or deformed.

2. Pipe-Interior Designation. The interior of a pipe is either smooth or corrugated. For most pipe structures and pipe types, the contractor will have a choice of pipe materials, of either interior designation. For the purpose of determining backfill quantities, a smooth interior should be assumed.

3. Backfill Method. The standard backfill methods are described below, and also shown on the INDOT *Standard Drawings*.

    a. Method 1. This method should be used for a structure to be placed under a new- or replacement-roadway mainline or public road approach, for a structure to be placed under a median embankment, or for a new structure to be placed under an existing roadway mainline or public road approach.

    b. Method 2. This method should be used for a structure to be placed under a drive in new or replacement work, or under an existing drive.

c. Method 3. This method should be used for a structure to be placed under a new- or replacement-roadway's median trench.

4. Backfill Material. Unless instructed otherwise, structure backfill is required for each culvert or storm-drain structure, except a field-entrance culvert which is to be backfilled with suitable excavated material.

The contractor may substitute coarse aggregate as an option for structure backfill for backfilling a concrete culvert, pipe, structural plate pipe, pipe-arch, or arch. However, the backfill material should always be identified as structure backfill. If coarse aggregate is used, the ends and top of the trench are to be capped with geotextile as shown on the INDOT *Standard Drawings*. The geotextile is not a separate pay item.

A specific backfill type should only be specified if, for example, a pipe is to be placed in the vicinity of utilities. Then, flowable backfill should be specified. If structure backfill or flowable backfill are both acceptable alternates, the material should be identified and quantified as structure backfill.

See the INDOT *Standard Drawings* to determine the appropriate backfill materials for the structure based on the backfill method required.

B. Hand-Calculation of Backfill Quantities

Figure 07-__A identifies the values described below which are required for determining backfill quantities in english measurement units.

1. Circular Pipe, Earth Foundation.

C_t = corrrugations thickness = 0.5 in.

$$B_c = H_c = \frac{Inside\,Dia. + 2C_t}{12}$$

T_c = trench cover depth over pipe

V_c = 1 ft for $B_c \leq 1.5$ ft, or 1.5 ft for $B_c > 1.5$ ft

For backfill method 1 or 2, $L_B = 2(5) + Pvmt.\ Width + 2\left[2(T_c + H_c)\right]$,
where $T_c = V_c$. The pavement width is that of the travel lanes plus shoulders.

For backfill method 3, or method 1 in a median embankmemt, $L_B = Median\ Width - 2[2(T_c + H_c)] - 2(5)$. The median width excludes the shoulder widths.

$$A_c = \frac{\pi(B_c)^2}{4}$$

$W = 0.3B_c$ or 0.75 ft, whichever is greater

$W_b = 2W + B_c$

$$K = 2W + B_c + \frac{2H_c}{12}$$

For backfill method 3, $K_3 = 2W + B_c + \frac{2(H_c + V_c)}{12}$

$$W_t = K + \frac{2T_c}{12}$$

All methods, backfill quantity, B_{BC}, per linear foot from trench bottom to pipe crown:

$$B_{BC} = \frac{[0.5H_c(W_b + K)] - A_c}{27}$$

Method 1 or 2 backfill quantity, B_{CT}, per linear foot from pipe crown to top of trench:

$$B_{CT} = \frac{T_c(K + W_t)}{54}$$

Method 3 backfill quantity, B_{CV}, per linear foot from pipe crown to top of V_c dimension:

$$B_{CV} = \frac{V_c(K + K_3)}{54}$$

Method 3 backfill quantity, B_{VT}, per linear foot from top of V_c dimension to top of trench:

$$B_{VT} = \frac{(T_c - V_c)(K_3 + W_t)}{54}$$

Method 1 backfill per linear foot = $B_{BC} + B_{CT}$.
Method 1 total backfill quantity = $L_B(B_{BC} + B_{CT})$.

For backfill method 2, B_{BC} and B_{CT} each represent different materials, so the quantities should not be added. The total quantity for method 2's B_{BC} material is $(L_B)(B_{BC})$. The total quantity for method 2's B_{CT} material is $(L_B)(B_{CT})$.

For backfill method 3, B_{BC} and B_{CV} are the same material, so the total method 3 quantity of this material is $L_B(B_{BC}+ B_{CV})$. B_{VT} represents a different material, so it should not be added to $B_{BC}+ B_{CV}$. The total quantity for method 3's B_{VT} material is $(L_B)(B_{VT})$.

2. Circular Pipe, Rock Foundation. The total backfill quantity is that required for an earth foundation plus the foundation backfill required below the pipe. The additional volume is determined as follows:

A = 8 in. or 2/3 ft. The entry in the formula below for W_F must be made in feet.

$$W_F = 2W + B_c - \frac{2A}{12}$$

Backfill quantity, B_F, per linear foot of foundation area:

$$B_F = A\left(\frac{W_b + W_F}{2}\right)$$

Total foundation-backfill quantity = $(L_B)(B_F)$

3. Deformed Pipe, Earth Foundation.

C_t = corrrugations thickness = 0.5 in.

$$B_c = \frac{Span + 2C_t}{12}$$

$$H_c = \frac{Rise + 2C_t}{12}$$

For backfill method 1 or 2, $L_B = 2(5) + Pvmt.\ Width + 2\left[2\left(T_c + H_c\right)\right]$,
where $T_c = V_c$. The pavement width is that of the travel lanes plus shoulders.

For backfill method 3, or method 1 in a median embankmemt,
$L_B = Median\ Width - 2\left[2\left(T_c + H_c\right)\right] - 2(5)$. The median width excludes the shoulder widths.

$$A_c = \frac{(Pipe\ Opening)(C_t)(P)}{12}$$

$W = 0.3B_c$ or 0.75 ft, whichever is greater

$W_b = 2W + B_c$

$$K = 2W + B_c + \frac{2H_c}{12}$$

All methods, backfill quantity, B_{BC}, per linear foot from trench bottom to pipe crown:

$$B_{BC} = \frac{[0.5H_c(W_b + K)] - A_c}{27}$$

Method 1 or 2 backfill quantity, B_{CT}, per linear foot from pipe crown to top of trench:

$$B_{CT} = \frac{T_c(K + W_t)}{54}$$

Method 3 backfill quantity, B_{CV}, per linear foot from pipe crown to top of V_c dimension:

$$B_{CV} = \frac{V_c(K + K_3)}{54}$$

Method 3 backfill quantity, B_{VT}, per linear foot from top of V_c dimension to top of trench:

$$B_{VT} = \frac{(T_c - V_c)(K_3 + W_t)}{54}$$

Method 1 total backfill per linear foot = $B_{BC} + B_{CT}$.
Method 1 total backfill quantity = $L_B(B_{BC} + B_{CT})$.

For backfill method 2, B_{BC} and B_{CT} each represent different materials, so the quantities should not be added. The total quantity for method 2's B_{BC} material is $(L_B)(B_{BC})$. The total quantity for method 2's B_{CT} material is $(L_B)(B_{CT})$.

For backfill method 3, B_{BC} and B_{CV} are the same material, so the total method 3 quantity of this material is $L_B(B_{BC} + B_{CV})$. B_{VT} represents a different material, so it should not be added to $B_{BC} + B_{CV}$. The total quantity for method 3's B_{VT} material is $(L_B)(B_{VT})$.

4. Deformed Pipe, Rock Foundation. The total backfill quantity is that required for an earth foundation plus the foundation backfill required below the pipe. The additional volume is determined in the same manner as for a circular pipe.

For a metric-units project, the english-units procedure described above should be used, with english-units pipe sizes. The final cubic-yards backfill quantities should be converted to cubic meters.

C. Computer Program for Determining Backfill Quantities

The computer program, Backfill Calculation Software, is now available on the Department's website at www.in.gov/dot/div/contracts/standards/07Bkfl-qt.xls, and will be included on the Department's Design and Construction Reference Guide CD dated September 2007. The program, along with its related reference sheets and examples, is currently available in english measurement units only. Use of the program precludes the need for hand-calculations. For a metric-units project, the final cubic-yards backfill quantities determined from use of the program should be converted to cubic meters.

For a circular pipe, the input data include pipe diameter, pavement or median width as required, and T_c.

For a deformed pipe, the input data include pipe size, pavement or median width as required, T_c, span, rise, and perimeter P. Span, rise, and P can be determined from the reference sheets included with the program.

The following backfill-quantities calculation examples are included with the program.

1. Method 1, Circular Corrugated Pipe, Rock Foundation
2. Method 1, Deformed Smooth-Interior Pipe, Earth Foundation
3. Method 1, Circular Smooth-Interior Pipe, Earth Foundation
4. Method 2, Circular Corrugated Pipe, Earth Foundation
5. Method 2, Circular Corrugated Pipe, Structural-Plate Metal, Rock Foundation
6. Method 2, Deformed Corrugated Pipe, Earth Foundation
7. Method 3, Circular Corrugated Pipe, Earth Foundation
8. Method 3, Deformed Corrug. Pipe, Structural-Plate Aluminum Alloy, Earth Foundation
9. Method 3, Deformed Corrugated Pipe, Structural-Plate Steel, Rock Foundation

IV. VIDEO INSPECTION

Video inspection will be required for each pipe that cannot be visually inspected. A structure which will require video inspection is 100% of the length of any pipe deemed by the designer to be difficult or impossible to visually inspect or is inaccessible for visual inspection. This would include locations considered to be in confined spaces. Commercial- and private-drive pipes will not be video inspected. This is a pay item, and should be applied as necessary to all non-underdrain pipe pay items, without regard to INDOT *Standard Specifications* reference number.

V. INFORMATION TO BE SHOWN ON PLANS

The backfill method, material, and quantity; geotextile quantity if applicable; and video-inspection quantity if applicable, should be shown in the Structure Data table for each pipe structure. For a metric-units project, the metric pipe sizes should be shown on the plans, even though english pipe sizes were used to determine the backfill quantities.

VI. RECURRING SPECIAL PROVISIONS AND RECURRING PLAN DETAIL

The Recurring Special Provisions and Recurring Plan Detail, all listed below and attached hereto, should be called for beginning with the March, 2007, letting, and through the August 22, 2007, letting. The bases for use are also listed below.

Document No. and Title	Basis for Use
211-R-534, B Borrow and Structure Backfill	Pay item for B borrow or structure backfill
714-R-535, Concrete Culverts and Retaining Walls	Pay item with *Standard Specifications* Section 714 reference number
715-R-536, Pipe Culverts and Storm and Sanitary Sewers	Pay item with *Standard Specifications* Section 715 reference number
715-R-536d, Recurring plan details for pipe-backfill methods	Pay item with *Standard Specifications* Section 211, 714, 715, 717, or723 reference number
717-R-537, Structural Plate Pipe, Pipe-Arches, and Arches	Pay item with *Standard Specifications* Section 717 reference number
904-R-538, Structure Backfill	Pay item with *Standard Specifications* Section 211, 714, 715, 717, or723 reference number

Beginning with the September 6, 2007, letting, the recurring special provisions will be incorporated into the INDOT *Standard Specifications* and the recurring plan detail will become the new INDOT *Standard Drawings* 715-BKFL- series. The provisions and detail will then no longer be required to be called for in specific contracts.

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Attachments

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